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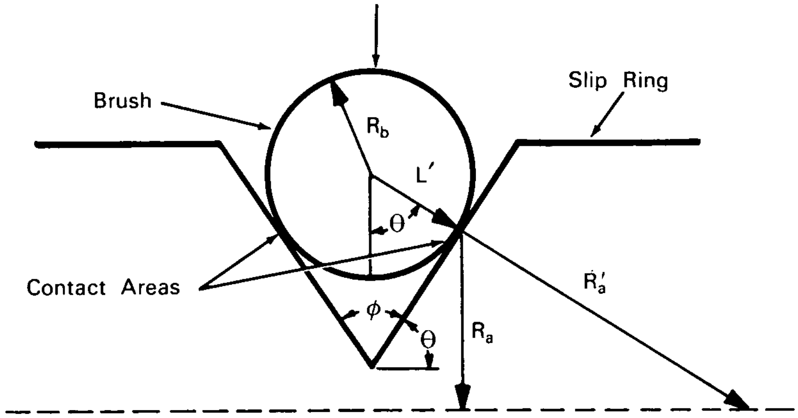
Contact Stresses Calculated For Miniature Slip Rings



The problem: In order to optimize the design of contact brushes and miniature slip rings, the stresses on the contact brush and ring must be known for various configurations and preloads applied to the brushes. In general the contact area between the brush and ring must be as large as possible to reduce the contact stresses which tend to roughen the surfaces, causing arcing and shortening the life of the assembly. The maximum contact area is governed by the amount of friction-caused mechanical constraint that can be tolerated.

The solution: Using the mathematical formulations given below, one can plot the graphs of the contact preload versus the Hertzian load. With these graphs the ideal configuration for the particular application can be obtained.

How it's done: The calculation of the unit loading of the preloaded brushes on slip rings assumes Hertzian stresses similar to those found in bearings. The mathematical analysis is based on the assumption that the brush and ring are of the same material. The Hertzian stress P for this application is given by

$$P = L'/A$$

where $L' = L \cos \Theta$

A = Area of Contact = πg^2

The area of contact A is dependent on the Hertzian function g which is given by

$$g = \sqrt[3]{\frac{3L'(1-J^2)\,R'_a+R_b}{E(R'_a + R_b)}}$$

where E is Young's modulus, J is Poisson's ratio, and R_b and R'_a are radii of the objects in contact.

From these equations, curves may be plotted varying the parameters of design, such as brush diameter, brush preload, groove angle (Θ), slip ring diameter (R_a), and material. An analysis of these curves will then help to obtain the optimum design.

(continued overleaf)

A set of curves using Hertzian load versus brush preload have been plotted for gold while varying the groove angle from 60° to 90°, brush diameter from 0.007 inch to 0.010 inch, and ring diameter from 0.14 inch to 0.35 inch. Contact stresses were found to be between 50,000 to 120,000 psi, with preloads varying between 2 and 16 grams. From the curves it was noted that contact stress varies exponentially with brush preload and the exponent is less than one. An increase in preload from 4 grams to 8 grams gives an increase in contact stress from only 72,000 psi to 90,000 psi. Also, small increases in brush diameter from 0.007 inch to 0.010 inch and a decrease in groove angle from 90° to 60° may result in as much as 30% reduction in contact stresses.

The contact area was found to be approximately 5×10^{-8} square inch, which may not give a stable contact with a surface finish of 5×10^{-6} inch (RMS) and the above configurations. It was also found that the change in ring diameter within 0.14 to 0.35 inch had little effect on the contact area.

Note: Inquiries concerning this innovation may be directed to:

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Reference: B65-10098

Patent status: NASA encourages commercial use of this innovation. No patent action is contemplated.

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